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Characteristics and Pedogenesis of Soils Developed over Talc at Odo-ogbe, Kogi State, Nigeria

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Abstract: Five soil profiles representing five mapping units delineated from a detailed survey of soils developed over talc in a southern guinea savanna agro-ecology of Kogi state, Nigeria, were studied to bridge the dearth of information on the characteristics and mineralogy of soils derived from talc in Nigeria. Morphological studies of the pedogenic horizons of each profile pit were carried out on the field and soil samples collected from these pedogenic horizons were subjected to routine soil analyses, clay fractionation and X-ray diffraction studies. The data generated from the above analyses, together with the morphological characteristics of the soils were used for the soil classification. Most horizons had greater than 700 g kg^{-1} sand, 150 g kg^{-1} clay and less than 150 g kg^{-1} silt. Thus the textures of these soils were predominantly sand, loamy sand and sandy loam. The soil reactions were generally slightly acidic to mildly alkaline (pH 4.77 - 6.91 in H_2O and 3.53 - 5.84 in molar KCl). The cation exchange capacity (CEC) values were low to moderate (4.30 cmol kg^{-1}-13.42 cmol kg^{-1}). The exchange sites of the soils were dominated by exchangeable calcium and magnesium with values ranging between 0.80 cmol kg^{-1} to 6.40 cmol kg^{-1} and 0.20 cmol kg^{-1} to 3.60 cmol kg^{-1}, respectively. The available phosphorus was moderate in the surface horizons (3.75 mg kg^{-1} to 32.00 mg kg^{-1}) and very low in the subsurface horizons (0.13 mg kg^{-1} to 2.00 mg kg^{-1}). The dominant clay minerals of the soils were kaolinite (0.72, 0.358 nm), degraded mica (1.0, 0.50 nm) and quartz (0.426, 0.34 nm). Interstratified (smectite/vermiculite) material (1.47 nm) occurred in trace only in the C horizon of Pedon OD2 while the B horizon of this same pedon (OD2) had noticeable quantity of interstratified mica-smectite (1.52 nm) with a high concentration of degraded mica. Detectable traces of feldspar and goethite also occurred in some of the pedons. Four pedons were classified as soil order Inceptisols (Cambisols) and the remaining pedon as soil order Ultisols (Acrisols).

Key words: Pedogenesis • Clay mineralogy • Talc • Guinea savanna

INTRODUCTION

The type of soil formed under a particular set of environmental conditions is a function of the parent material and time [1]. The earlier studies conducted on the soils of various regions of Nigeria and the subsequent classifications [2, 3 4 and 5] were based mainly on the soil parent materials at the higher category classes. Literature reveals that several works have been done in Nigeria on the characteristics, mineralogy and classification of soils developed over sandstones, granite, gneiss and marble [6, 7, 8, 9, 10 and 11]. Other works [12, 13 and 5] which covered large parts of Northern Nigeria and the present middle belt were over-generalized and carried out at a reconnaissance scale with most of the parent materials being generally regarded as basement complex. However, there is dearth of information on the characteristics, mineralogy and classification of soils developed over talc, which is a major parent material in the southern Guinea savanna agro-ecological zone of Kogi state of Nigeria. Large deposits of this mineral are found in Ejiba, Odo-Ogbe and Okolom in Kogi state. Incidentally, these areas are well known for the production of many staple crops in addition to few tree crops like cashew, citrus and mango. This study was therefore designed to bridge the dearth of information on the characteristics and mineralogy of soils derived from talc in Odo-Ogbe (OD) in the southern Guinea savanna agro-ecological zone of Nigeria.

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MATERIALS AND METHODS

Soil survey in the selected site was conducted using the rigid grid method with horizontal and vertical traverses cut at 50m interval and at right angle to one another. This resulted in the delineation of five mapping units within the selected site. Profile pits were dug in each of the five delineated mapping units and soils of the pedogenic horizons of each profile were studied morphologically in situ. Soil samples collected from the genetic horizons of each profile were air-dried and passed through a 2mm sieve. Particle size distribution was determined by the hydrometer method [14] after the removal of organic matter with hydrogen peroxide and dispersion with sodium hexametaphosphate [15]. The pH was determined with glass electrode pH meter in soil: water and soil: KCl media, each at ratio 1: 1. Exchangeable cations (calcium, magnesium, potassium and sodium) were extracted with neutral normal ammonium acetate (NH_4OAc at pH 7.0). Calcium and magnesium in the ammonium acetate extract were determined by atomic absorption spectrophotometry, while potassium and sodium were determined by flame photometry. Cation Exchange Capacity (CEC) was determined according to the procedure of Hossner [16]. Organic matter was determined by the wet oxidation method [17]. For mineralogical analyses, the clay fraction (<2µm) was separated from soil samples taken from the A, B and C horizons of profiles OD2, OD3 and OD4 by repeated dispersion and centrifugation after the hydrogen peroxide pre-treatment [18]. Removal of iron oxide from the clay sample was done with the dithionite-citrate-bicarbonate method [19]. Preparation of oriented clay slides for x-ray analysis was carried out as outlined by Jackson [20]. X-ray diffraction patterns were obtained for Mg-saturated and glycerol-solvated clay samples. A similar diffraction pattern was obtained for the K-saturated and glycerol solvated sample after heating to 550°C for 12 hours. The samples were run using Cu-Kα radiation with goniometer run from 2° 2θ to 40° 2θ at a speed of 2° per minute and 1000 counts per second for each of the slides. The data generated from the above analyses were used with the morphology of the soils for the soil classification.

RESULTS AND DISCUSSION

Soil Morphological Properties: Odo-Ogbe soils had sand content that ranged in values between 700.60 g kg^{-1} and 900.20 g kg^{-1}. The values of silt in the soils were comparatively lower than the values of the sand fractions and ranged in values between 40.40 g kg^{-1} and 100.00 g kg^{-1} in the surface soils, while the subsurface horizons had silt contents ranging in value between 60.00 g kg^{-1} to 130.00 g kg^{-1}. The clay contents of these soils increased with depth (gradational texture) and with argillic horizon occurring in pedons OD2 and OD3, which had duplex texture. The surface horizons had clay that ranged in value from 34.00 g kg^{-1} to 54.00 g kg^{-1} while the subsurface horizons had clay values that ranged from 54.00 g kg^{-1} to 164.00 g kg^{-1}.

The textures of these soils were predominantly sand, loamy sand and sandy loam while the soil structural classes ranged from granular to fine-sub-angular-blocky in the surface horizons and medium to coarse sub-angular blocky structures in the subsurface horizons. The surface soils had different shades of colour ranging from black, dark brown, very dark brown to dusky red. Apart from profile 3, the general colour hue of the surface soils were between 7.5YR and 10YR. Profile 3 had a colour in the red hue (2.5YR) range. The subsurface colour ranged between dark yellowish brown (10YR 4/4) to dark red (2.5YR 3/6). Mottling occurred in the last two horizons of pedons OD1 and OD2, while in pedon OD3 only the last horizon was mottled. Pedon OD5 had mottles in the last four horizons and the colour of the mottles varied between different shades of brown and grey. Mottling in profiles 5 was the result of high seasonal water table. The presence of plinthic horizon, which caused drainage impediment probably, resulted in the mottling observed in pedons OD1 and OD2.

Soil Chemical Properties: The soil pH in H_2O ranged in values between 4.77 and 6.91 and between 3.53 and 5.84 in 1molar KCl. Few of the soils have acidity problem (pH <5.0) and this was limited in most cases to the subsurface soils. The surface soils in most cases were in the low acidity range (pH 6.0-6.9). However, more than 60% of the soils were slightly acidic (pH 5.0-5.9) and so, ideal for most arable crops grown in this area [21, 22]. The surface horizons had values of TEA that ranged between 0.40 cmol kg^{-1} and 0.44 cmolkg^{-1}, while the subsurface soils had TEA values ranging from 0.40 cmolkg^{-1} to 0.64 cmolkg^{-1}.

Like in most tropical soils, the exchange sites of these soils were dominated by exchangeable calcium and magnesium. The exchangeable calcium (Ca^{2+}) ranged in values between 2.60 cmol kg^{-1} and 6.00 cmol kg^{-1} in the surface soils and varied from 0.80 cmol kg^{-1} to 6.40 cmol kg^{-1} in the subsurface soils. Magnesium (Mg^{2+}) contents varied from 1.20 cmol kg^{-1} to 2.00 cmol kg^{-1} and

Table 1: Physical and Morphological properties of the soils developed over Talc overburden in Odo-Ogbe

Field ID	Horizon Depth (cm)	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	Gravel (g kg^{-1})	Soil texture	Soil structure	Soil colour (moist)
OD1-A1	0-10	870.60	90.00	30.40	5.50	S	G	Dark grayish brown (10YR 4/2)
OD1-A2	10-28	880.60	80.00	30.40	35.50	S	MSAB	Dark yellowish brown (10YR 4/6)
OD1-B1	28-45	880.60	60.00	50.40	55.00	S	MSAB	Dark yellowish brown (10YR 4/4)
OD1-B2	45-105	780.60	130.00	80.40	57.50	SL	MSAB	Strong brown (7.5YR 4/6); Light brownish gray mottles (2.5YR 6/2)
OD1-C	105-140	780.60	70.00	140.40	267.00	SL	MSAB	Yellowish red (5YR 5/8); Light brownish gray mottles (2.5Y 6/2)
OD2-A	0-15	850.60	100.00	40.40	3.50	LS	MSAB	Dark brown (7.5YR 3 /4)
OD2-B1	15-43	770.60	100.00	120.40	3.50	SL	CSAB	Dark brown (7.5YR 4/4)
OD2-B2	43-110	700.60	110.00	180.40	57.50	SL	CSAB	Weak red (2.5YR 5/2); Strong brown mottles (7.5YR 5/8)
OD2-C	110-140	700.60	110.00	180.40	60.00	SL	CSAB	Weak red (2.5YR 5/2); Strong brown mottles (7.5YR 5/8)
OD3-A	0-9	860.60	90.00	40.40	0.00	S	MSAB	Very dusky red (2.5YR 2.5/2)
OD3-B	9-120	750.60	90.00	150.40	0.00	SL	MSAB	Dark reddish brown (2.5YR 3/ 4)
OD3-C	120-180	790.60	110.00	90.40	0.00	SL	MSAB	Dark red (2.5YR 3/6); Very pale brown mottles (10YR 7/3)
OD4-A	0-10	890.60	50.00	50.40	105.50	S	FSAB	Black (10YR 2/1)
OD4-B1	10-30	900.20	40.40	50.40	153.50	S	FSAB	Dark yellowish brown (10YR 3 /4)
OD4-B2	30-95	820.20	70.40	100.40	287.50	LS	MSAB	Dark red (2.5YR 3/6)
OD4-C	95-140	740.20	100.40	150.40	329.90	LS	MSAB	Red (2.5YR 4/6)
OD5-A1	0-14	840.20	90.40	60.40	0.00	S	FSAB	Very dark brown (10YR 2/2)
OD5-A2	14-32	840.20	100.40	50.40	0.00	S	FSAB	Very dark grayish brown (10YR 3/2)
OD5-A3	32-51	830.20	120.40	40.40	0.00	S	FSAB	Brown (10YR 5/3)
OD5-B1	51-69	900.20	40.40	50.40	0.00	S	FSAB	Yellowish brown (10YR 5/6); Olive brown mottles (2.5Y 4/4)
OD5-B2	69-97	840.20	70.40	80.40	55.00	S	MSAB	Yellowish brown (10YR 5/8); Light yellowish brown mottles (2.5Y 6/4)
OD5-C1	97-105	860.20	60.40	70.40	57.50	S	MSAB	Yellowish brown (10YR 5/8); Light brownish gray mottles (2.5Y 6/2)
OD5-C2	105-180	760.20	70.40	160.40	0.00	SL	MSAB	Yellowish brown (10YR 5/8); Light gray (2.5Y 7/0)

S = sand; SL = Sandy Loam; LS = Loamy Sand; SCL = Sandy Clay Loam; FSAB = Fine Sub Angular Blocky; MSAB = Medium Sub Angular Blocky; CSAB = Coarse Sub Angular Blocky; PR = Prismatic; G = Granular

Table 2: Chemical properties of soils developed over talc overburden in Odo-Ogbe

Field ID	Horizon depth (cm)	pH (H_2O) 1:1	pH (Kcl) 1:1	% OC	Total acidity	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	ECEC	CEC	PBS (%)	P (mg kg^{-1})
						cmol kg^{-1}							
OD1-A1	0-10	6.40	5.60	1.67	0.40	3.60	1.80	0.35	0.29	6.44	8.48	71.23	11.25
OD1-A2	10-28	5.55	4.60	1.63	0.48	3.80	2.40	0.33	0.31	7.32	10.00	68.40	0.13
OD1-B1	28-45	5.70	4.57	1.67	0.44	5.20	3.20	0.43	0.30	9.57	10.38	87.96	0.25
OD1-B2	45-105	6.47	5.38	0.80	0.36	4.80	2.40	0.41	0.29	8.26	11.14	70.92	1.38
OD1-C	105-140	6.91	5.84	0.76	0.36	4.80	2.20	0.35	0.26	7.97	13.42	56.71	0.13
OD2-A	0-15	5.83	4.74	1.29	0.44	2.60	1.20	0.31	0.22	4.77	5.46	79.30	10.13
OD2-B1	15-43	4.88	3.60	0.80	0.52	3.00	0.40	0.39	0.21	4.52	6.58	60.79	2.38
OD2-B2	43-110	5.86	4.84	0.61	0.48	6.40	2.80	0.48	0.22	10.38	11.14	88.87	5.38
OD2-C	110-140	5.85	4.80	0.60	0.44	4.00	1.40	0.43	0.27	6.54	10.76	56.69	5.63
OD3-A	0-9	6.31	5.21	1.44	0.40	4.10	0.90	0.29	0.17	5.86	6.96	78.45	12.63
OD3-B	9-120	5.11	4.66	0.76	0.48	1.60	0.40	0.29	0.18	2.95	9.24	26.73	4.25
OD3-C	120-180	5.55	4.72	0.53	0.48	2.00	1.00	0.26	0.28	4.02	6.20	57.10	0.13
OD4-A	0-10	6.12	5.40	2.89	0.40	6.00	2.00	0.47	0.20	9.07	11.14	77.83	32.00
OD4-B1	10-30	5.09	4.70	1.56	0.52	1.40	0.40	0.30	0.20	2.82	5.06	45.45	7.75
OD4-B2	30-95	4.77	3.53	0.95	0.64	1.20	0.60	0.26	0.30	3.00	6.20	38.06	0.13
OD4-C	95-140	4.80	3.63	0.72	0.64	1.40	0.20	0.31	0.23	2.78	4.30	49.77	0.13
OD5-A1	0-14	5.99	5.13	2.09	0.40	4.40	1.80	0.47	0.25	7.32	10.38	66.67	3.75
OD5-A2	14-32	5.34	4.73	0.99	0.48	1.40	0.60	0.23	0.25	2.96	5.06	49.01	6.88
OD5-A3	32-51	5.45	4.80	0.72	0.48	0.80	0.60	0.21	0.26	2.35	4.30	43.49	0.13
OD5-B1	51-69	5.75	4.95	0.57	0.44	0.80	0.80	0.19	0.20	2.43	4.68	42.52	1.00
OD5-B2	69-97	5.94	5.05	0.57	0.40	1.00	0.60	0.24	0.26	2.50	4.68	44.87	1.00
OD5-C1	97-105	5.64	4.38	0.57	0.44	1.20	0.80	0.27	0.37	3.08	5.44	48.53	0.25
OD5-C2	105-180	5.90	4.52	0.65	0.40	2.20	3.00	0.30	0.33	6.23	10.00	58.30	0.13

between 0.20 cmol kg^{-1} and 3.20 cmol kg^{-1} for the surface and subsurface soils respectively. Exchangeable K^+ was moderate in the surface horizons and had values between 0.21 cmol kg^{-1} and 0.47 cmol kg^{-1} and between 0.19 cmol kg^{-1} and 0.48 cmol kg^{-1} in the sub-surface horizons. Apart from the subsurface-soils of pedon OD5, all the pedons had values of exchangeable calcium well above the suggested critical value (1.50-2.0 cmol kg^{-1}) for most arable crops grown in the southern guinea savanna agro-ecology of Nigeria [21, 22]. This means that Ca^{2+} supply should not limit crop production in these soils. Similarly, with 0.16 cmol kg^{-1} and 0.28 cmol kg^{-1} as the suggested critical levels of exchangeable K and Mg respectively. These soils could be adequately enriched in exchangeable K and Mg and may not likely respond to applied K and Mg [21, 22, 23]. Exchangeable sodium (Na^+) was low. The surface soils had Na^+ values between 0.17 cmol kg^{-1} and 0.29cmol kg^{-1} while the subsurface soils had Na^+ values that range between 0.18cmol kg^{-1} and 0.37cmol kg^{-1}. The values of Na^+ recorded in this study were similar to those recorded for the soils of Abugi [10].

The effective cation exchange capacity (ECEC) for the surface soils varied from 4.77 cmol kg^{-1} to 9.07 cmol kg^{-1}, while the CEC varied from 5.46 cmol kg^{-1} to 11.14 cmol kg^{-1}. The subsurface soils on the other hand had ECEC values between 2.35 cmol kg^{-1} and 10.38 cmol kg^{-1} with CEC values varying between 4.30 cmol kg^{-1} and 13.42 cmol kg^{-1}. The values of CEC were higher than those of ECEC, but the differences in value between CEC and the corresponding ECEC were not more than 20%. Percentage base saturation (PBS) values ranged between 66.67% and 79.30% in the surface soils and from 26.73% to 88.87% in the sub surface soils. In most of the profiles, the PBS of the surface soils were higher than those of the subsurface soils and the sum of Ca^{2+} and Mg^{2+} accounted for more than 90% of the TEB and CEC.

Organic carbon content of the surface soils ranged between 1.20% and 2.89% while the subsurface horizons had organic carbon contents that ranged from 0.53% to 1.63%. Most of the surface soils had values of organic carbon well above the critical level of 1.2% [22]. The subsurface soils had low (0-1.2%) content of organic carbon. However, the values of organic carbon content of these soils compares favourably with the 0.8-1.06% reported as the average for the soils of the savanna zone of south west Nigeria [22].

Available P was moderate in the surface soils and the values ranged between 3.75 mg kg^{-1} and 32.00 mg kg^{-1} while the subsurface horizons had values of available P between 0.13 mg kg^{-1} and 6.88 mg kg^{-1}. The highest value of 32.00 mg kg^{-1} was recorded in the surface soil of profile 3 and was probably caused by prolonged manuring resulting from accumulation of livestock dung due to the occupation of the area by grazing cow for a period of more than six years. There were sharp decreases in the values of available P with increasing soil depth. The subsurface soil contents of available P were very low and once the surface soil is depleted of available P, there will be P deficiency.

Clay Mineralogy: X-ray diffraction patterns (Fig. 1, 2 and 3) of clay samples from Odo-Ogbe soils revealed that the soils were dominated by kaolinite, quartz and degraded mica with traces of feldspar, rutile, smectite and goethite. The x-ray patterns revealed the presence of kaolinite in the magnesium saturated and glycerol solvated samples (0.716-0.717nm and 0.357-0.358nm). These peaks disappeared in the potassium saturated and glycerol solvated samples that were heated to 550°C. This confirmed the presence of kaolinite in the clay samples of Odo-Ogbe soils. The kaolinite peaks were more intense than the other peaks in pedons OD2 and OD4, thus indicating that kaolinite occurred in greater quantity than all other clay minerals in these two pedons. The peaks at 0.425, 0.426, 0.335, 0.337 and 0.339 nm in both magnesium and potassium saturated and glycerol solvated samples indicated the presence of quartz in the clay samples (Fig. 1, 2 and 3). Magnesium saturated and glycerol solvated samples also showed low intense mica peaks (0.997-1.01 and 0.497-0.512nm). These peaks were equally noticed in the potassium saturated and glycerol solvated samples and the peaks persisted and became more enhanced on heating the K-saturated samples to 550°C. The peaks at 0.333, 0.337 and 0.339 nm (Fig. 1, 2 and 3) indicated the presence of either quartz or mica. Interstratified (smectite/vermiculite) material (1.47nm) occurred in trace only in the C horizon of Pedon OD2. The B horizon of this same pedon (OD2) had noticeable quantity of interstratified mica-smectite with a high concentration of degraded mica. The presence of interstratified mica-smectite was indicated by 1.52nm peak in the magnesium saturated and glycerol solvated sample. This (1.52nm) peak collapsed and shifted to 1.00nm on heating the potassium saturated and glycerol solvated sample to 550°C. Also trace of rutile (0.284-0.286 nm) was observed especially in the A and B horizons of all the pedons at Odo-Ogbe. A trace of goethite (0.417nm) was noticed in the magnesium saturated and glycerol solvated sample of the B- horizon of pedon OD4 (Fig. 3).

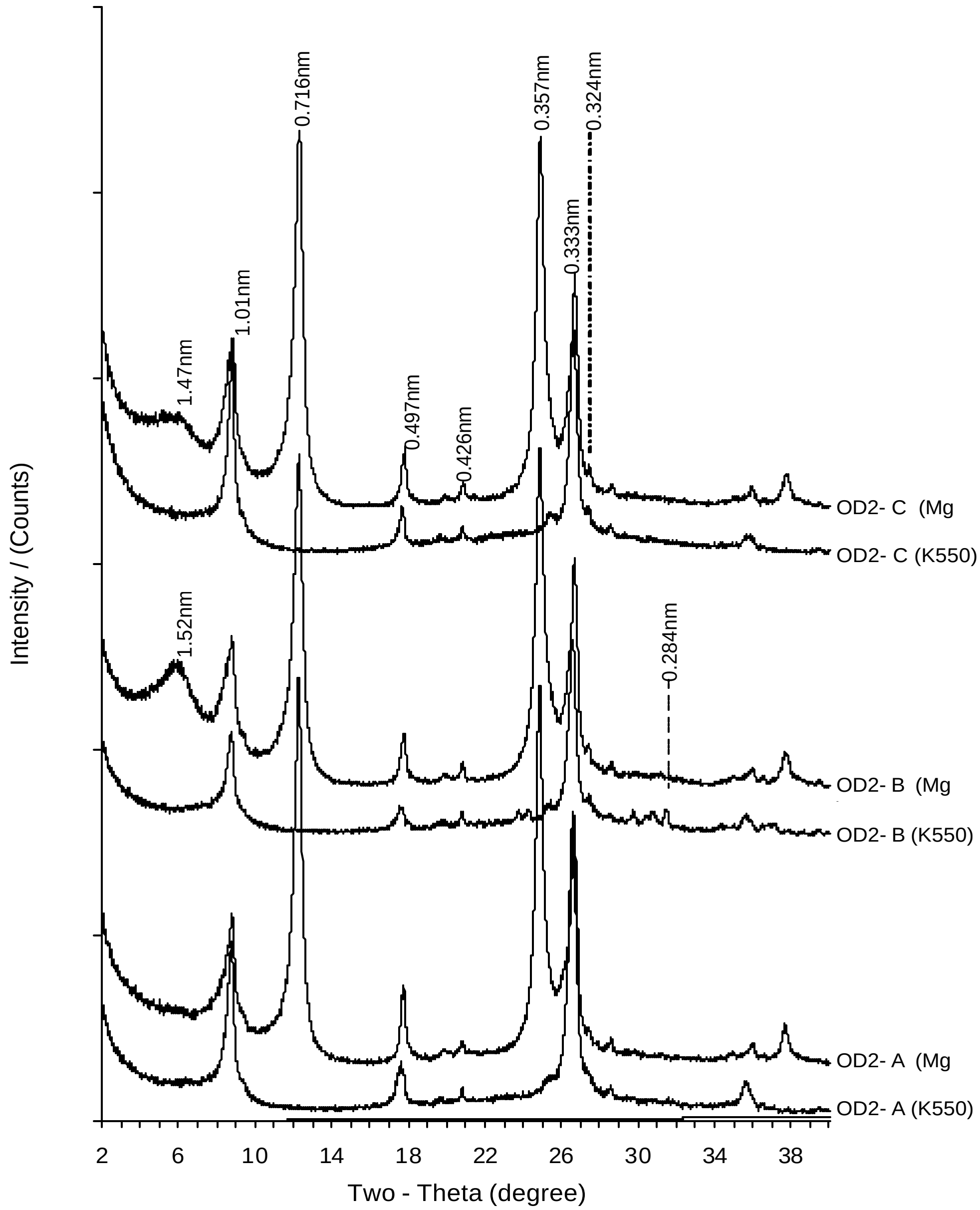

Fig. 1: X-ray diffractogram of Pedon OD2 at Odo - Ogbe
OD2 = Pedon Number; A, B, C = Horizons, Mg= Magnesium saturated and Glycerol solvated; K550 = Potassium saturated and glycerol solvated heated to $550^{O}C$

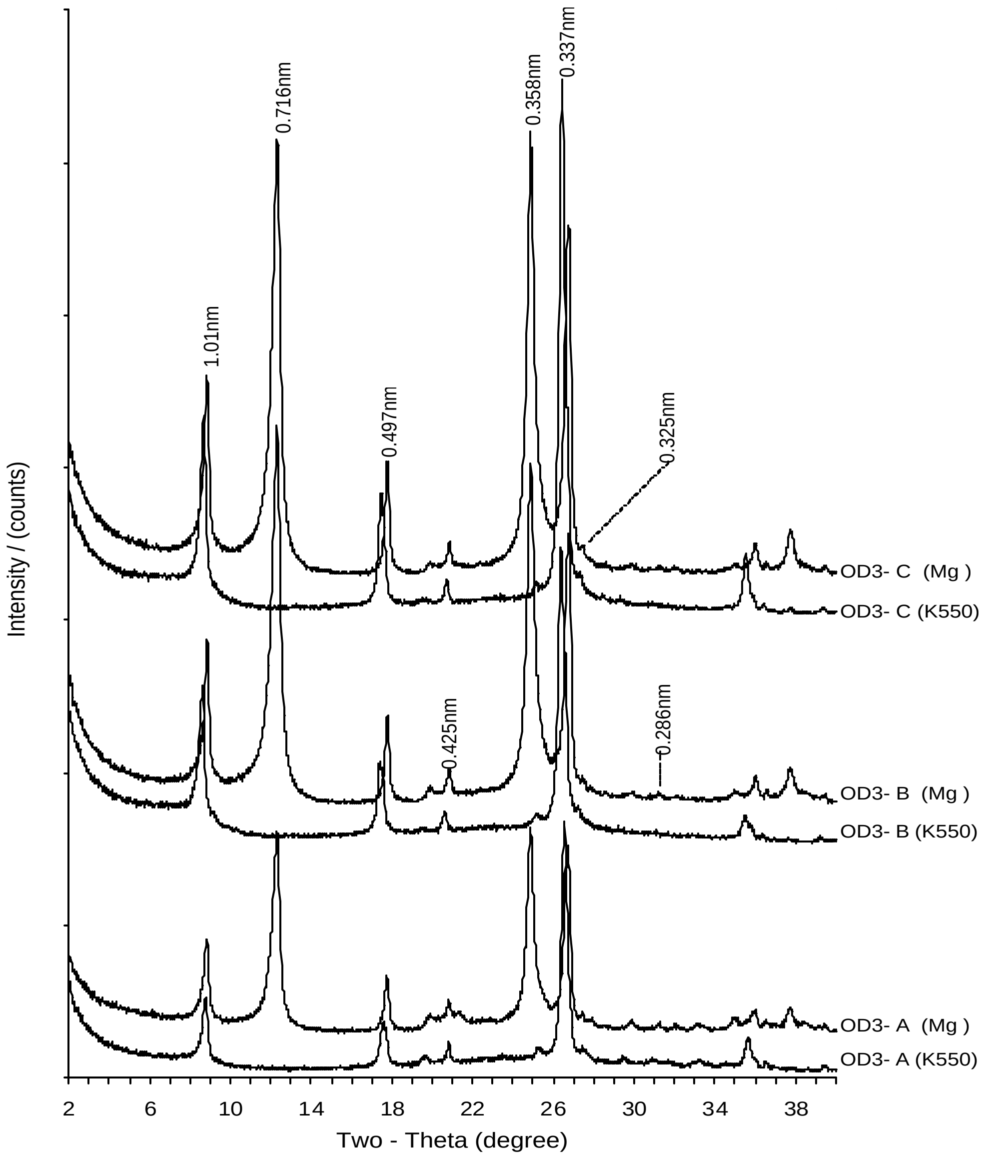

Fig. 2: X-ray diffractogram of Pedon OD3 at Odo – Ogbe

OD3 = Pedon Number; A, B, C = Horizons, Mg= Magnesium saturated and Glycerol solvated; K550 = Potassium saturated and glycerol solvated heated to 550^{O}C

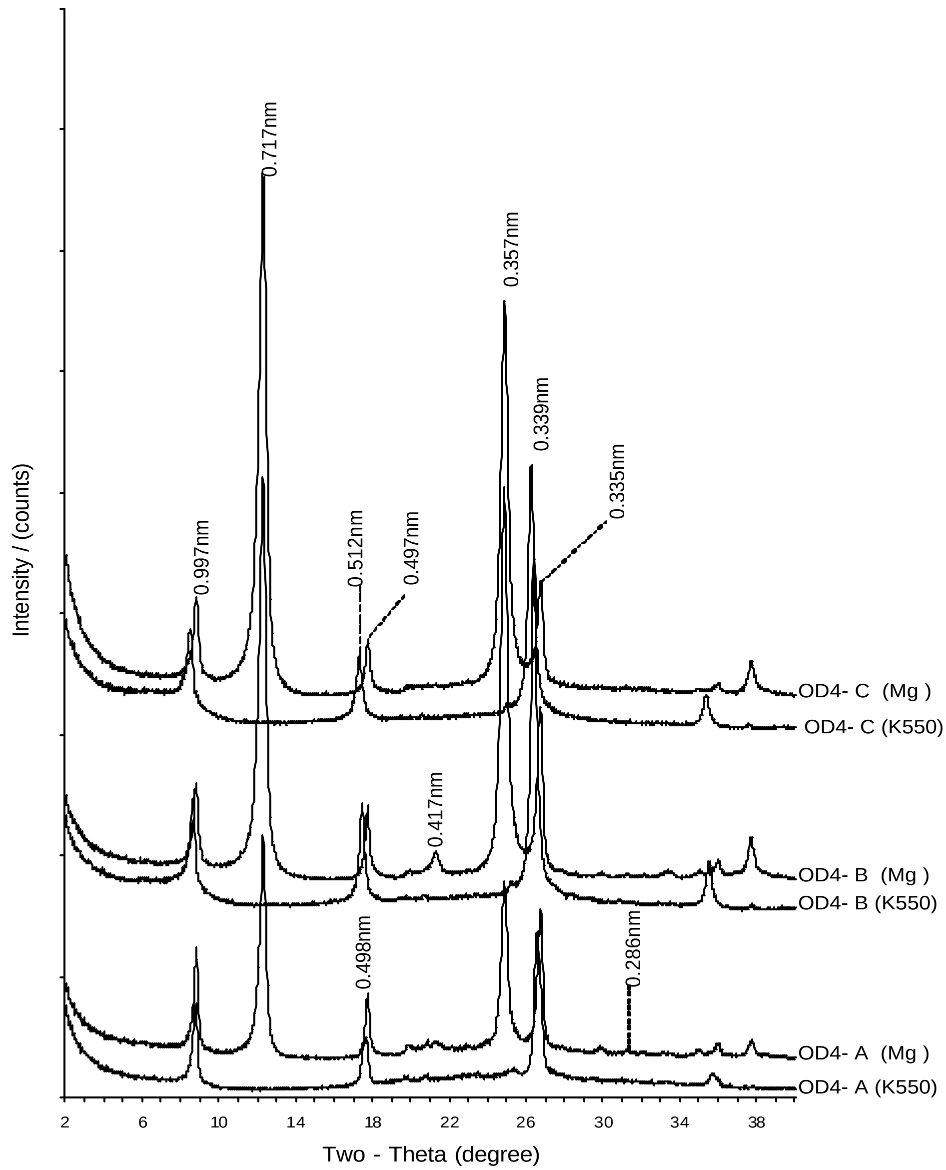

Fig. 3: X-ray diffractogram of Pedon OD4 at Odo - Ogbe

OD4 = Pedon Number; A, B, C = Horizons, Mg= Magnesium saturated and Glycerol solvated; K550 = Potassium saturated and glycerol solvated heated to 550^{O}C

Traces of K-feldspar (0.324-0.325 nm) were observed mainly in the potassium saturated and glycerol solvated samples taken from the C-horizons (Fig. 1 and 2).

The presence of micaceous mineral is typical of young parent materials in tropical environment [24]. Olivine is often altered by magmatic and metamorphic transformation to orthopyroxenes, serpentines or talc [25]. Wilson [26] reported that further weathering of enstatite to talc in a mafic rock followed a definite topotactic reaction with strict crystallographic continuity where the (100), (001) and (010) of the pyroxene became the (100), (001) and (010) of talc respectively. Further weathering resulted in the orientation relationship being lost with progressive replacement of talc by smectite and sometimes by smectite-chlorite. These transformations occurred by an initial preferential release of calcium and magnesium for structural reasons [27]. Wilson [26] stated that the weathering product formed might undergo further drastic transformations, usually involving the formation of a complex kaolinitic and iron oxide minerals. This is to say that the type of clay mineral found in a soil environment is an indication of the intensity of weathering of such soils. In the case of soils formed on talc in Odo- Ogbe for instance, smectite seems to be the first weathering product, while kaolinite and other iron oxide minerals appear at more advanced stages of weathering. The presences of these resistant minerals (Rutile, Ilmenite, Goethite and Quartz) indicated that these soils were at the intermediate to advance stages of weathering.

Classification of the soils of Odo-Ogbe: The soils of Odo-Ogbe were classified according to the USDA and World Reference Base taxonomy systems [28, 29]. In classifying these soils, certain criteria were considered. These include the nature of the epipedon, the type of illuvial or diagnostic master horizon, the cation exchange capacity of the soils, the percentage base saturation estimated on the basis of the CEC, the soil organic carbon content, the presence or absence of concretions (plinthites, duripan), the presence or absences of cutans, the soil drainage characteristics, the soil temperature and moisture regimes and the colour of the soils.

Classifications into the USDA order, sub-order, great group and sub group were done mainly on the basis of diagnostic horizons; the properties of the soils that reflect the nature of the soil environment and the dominant pedogenic processes that are responsible for the soil formation. Accordingly, Pedons OD1, OD2, OD4 and OD5 were classified as order Inceptisols (Cambisols) and sub order Ustepts because these pedons had cambic-B horizons and ustic moisture regime. Pedons OD1 and OD2 were further classified into the great group Haplustepts. Pedon OD1 was classified as Aquic Haplustepts (Endogleyic Cambisols) because the lower horizons of this pedon were temporarily saturated with water during the months of August to October causing the development of mottles with more than 30 percent redoximorphic colours (bluish to greenish colour (Munsell 2.5 Y)) in these horizons. This pedon also had a high percent base saturation, thus it was classified as Endogleyic Cambisols (Eutric). Pedon OD2, which also had reddish sub-surface horizon colour, was however classified as Typic Haplustepts (Cambisols (Rhodic)). Pedons OD4 and OD5 on the other hand were classified into great group Dystrustrepts (Cambisols (Dystric)) because these pedons had percent base saturation (by NH_4OAc method) less than 50% in all the horizons between a depth of 25cm from the mineral soil surface and 100cm. Pedon OD4 was further classified as Typic Dystrustepts while pedon OD5 was classified as Aquic Dystrustepts (Endogleyic Cambisols (Dystric)) because of the redoximorphic properties exhibited by the lower horizons of this pedon. Pedon OD4, which had a high gravel content (very many, large sub-angular feldspartic and quartzite stones) and reddish sub-surface horizons colour was classified further as Plinthic Cambisols (Dystric, Rhodic).

Pedon OD3, which had argillic horizon with percent base saturation (by NH_4OAc method) less than 35% was, classified as order Ultisols (Acrisols) and sub order Ustults because of the soil moisture regime that was ustic. The soil colour of this pedon was reddish throughout the profile having a colour hue of 2.5 YR in the sub-surface horizons. This criterion was used in classifying the pedon into great group Rhodustults (Acrisols (Rhodic)). This pedon was further classified as Typic Rhodustults.

Pedogenic Trends: The soils of Odo-Ogbe are still active with pedogenic processes going on. However, four main pedogenic processes were visibly noticed as being predominant at the present developmental stages of these soils. These processes include the loss of basic cations through leaching and clay synthesis (Laterization), the immobilization of clay from the surface soils and its subsequent deposition in the subsurface soils (argilluviation /lessivage), the development of mottling and gleying due to imperfect drainage caused either by the presence of drainage impediments or the occurrence of high seasonal water table leading to redoximorphic conditions (Gleization) and development of plinthic horizons due to the combined effects of the occurrence of high levels of Fe and Mn oxides in a redoximorphic environment coupled with alternate wetting and drying caused by fluctuating seasonal water table (Plinthization).

These different pedogenic processes were noticed either uniquely or in combination and operated at different rates in the different sections (surface and subsurface horizons) of the soils. For instance, the processes of argilluviation were noticed only in pedon OD3, which had a weakly developed argillic horizon. Also plinthization process was encountered in pedon OD1. However, leaching of the basic cations (Mg^{2+}, Ca^{2+}) leading to the gradual acidification of the subsurface soils occurred in most of the pedons. In the same vein, the processes of weathering and clay transformation seemed to have reached an advanced stage in these soils because the occurrence of smectite, which is regarded as the first transformation product of talc, was not encountered, instead interstratified (smectite/vermiculite) material occurred in trace only in the C horizon of Pedon OD2. The B horizon of this same pedon (OD2) also had noticeable quantity of interstratified mica-smectite with a high concentration of degraded mica.

Mottling occurred in all but one pedon. These pedons had redoximorphic horizons due to imperfect drainage caused either by the presence of drainage impediments or the occurrence of high seasonal water (Gleization). All the pedons with redoximorphic properties lied close to seasonal rivers and occupied the lowest area of the catena, except pedon OD1, which had drainage impediment caused by the presence of plinthic C- horizon.

CONCLUSION

The sand fractions of the soils were more relevant to textural classification than the silt and clay fractions.

The soil had strongly acidic to mildly alkaline reactions. The cation exchange capacity (CEC) values reflect the nature of the predominant clay minerals of the soils. Exchangeable calcium and magnesium accounted for more than 75% of the total exchangeable bases in these soils. Four pedons were classified as Inceptisols and the remaining pedon as Ultisols.

Sustainable crop production on these soils will require the maintenance of the productive potentials of the soils by cautious use of fertilizers and continuous use of leguminous cover crops.

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